SCIENTIFIC NOTE

Development, Evaluation and Sensory Quality of Orange Fleshed Sweet Potato (*Ipomoea batatas* Lam) Extruded Pasta Products

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Abstract

Orange fleshed sweet potatoes are rich in complex carbohydrates, dietary fiber, β-carotene, vitamin C and vitamin B_6, but are industrially underutilized in Africa due to its bulkiness and quick deterioration. The orange fleshed sweet potatoes (OFSP) were processed into flour using different processing methods with pretreatment (control, blanching, steaming, grilling) and extruded using extruder machine. Proximate, functional and chemical analysis of the OFSP flour was determined using standard methods. The OFSP was processed into extruded pasta products and the sensory properties were evaluated using a 9-point hedonic scale. Data obtained were subjected to analysis of variance and significant means were separated using Duncan multiple range test. Range of values for moisture, protein, fat, fibre, ash and carbohydrate were 7.76-8.49%, 3.14-6.57%, 13.94-25.66%, 2.83-3.20%, 2.70-3.01% and 56.31-68.45%, respectively. Processing methods significantly ($p<0.05$) affect the functional properties of the OFSP flour except the loose and pack bulk density. Range of values for tannin, total carotenoid, total sugar and damage starch were 779.2-993.6%, 39.48-67.06μg/100g, 2.30-6.83% and 2.91-3.43%, respectively. However, the samples based on their pretreatment and processing method were accepted by the panelist. The study showed that OFSP could be used for pasta production that is rich in beta carotene.

Keywords: *Orange fleshed sweet potato, extrudates, functional properties, sensory attributes*

Introduction

Sweet potato ranks the seventh most important food crop in the World and fourth in the tropical countries (Waramboi *et al*., 2010). In comparison to other staple food crops, sweet potato has the following positive attributes; wide production geography, adaptability to marginal condition, short production cycle, high nutritional value and sensory versatility in terms of flesh colors, taste and texture. Reports shows that sweet potatoes are rich in β-carotene, antocyanins, total phenolics, dietary fibre, ascorbic acid, folic acid and minerals (Woolfe, 1992; ILSI, 2008)

In Nigeria, sweet potato is mostly consumed as a snack, roasted, boiled, used with fresh yams in pounded yam and as a sweetener in beverage production. Processing sweet potato into flour or other food products would increase its utilization, serve as a source of nutrients such as carbohydrates, beta-carotene (pro vitamin A), vitamin C, vitamin B_6, and minerals such as calcium, phosphorus, iron, potassium, magnesium and zinc (Agbor-Egbe and Richard, 1990; Purseglove, 1991). OFSP can contribute to the colour, flavor and dietary fibre of processed food products such as bread, pasta products, and in other food preparations (Ofori *et al.,* 2009).

National Root Crops Research Institute, Umudike, Nigeria arranged and acquired some yellow and orange fleshed sweet potato genotypes with improved agronomic traits from International Potato Centre, Lima, Peru (known by its Spanish acronym, CIP) through its substation in East Africa. Sweet potatoes especially OFSP were bred as a tool for the global fight against vitamin A deficiency in areas that lack vitamin A rich food materials (Degras, 2003). Orange flesh sweet potato has been reported to increase vitamin A intake and serum retinol concentrations in children (Ajanaku *et al.,* 2013). The development of extruded pasta products from orange fleshed sweet potato flour will therefore play a major role in raising awareness on the potential of the crop.

Extrusion processing is a form of manufacture that involves the forcing of a material out of chamber or cylinder through a small opening by taking advantage of pressure differentials that exist between the internal and exterior of the chamber. Extrusion cooking of starchy materials had become a widely used technique to obtain a wide range of product such as snacks, breakfasts, cereals, special flours. There is dearth information on the application of extrusion cooking on processing of sweet potato, hence a need to explore the possibility of applying extrusion cooking for creating diversified increased consumption in OFSP. Therefore, the aim of the study is to examine the selected processed parameter in extrusion of orange flesh sweet potato on physicochemical and sensory properties of its extrudates.

Materials and Methods

Materials

Orange fleshed sweet potato was purchased from Owode market, Offa Kwara State and also from the experimental farm field of Federal Polytechnic, Offa. Equipment such as knife, bowl laboratory, gas cooker, milling machine, cabinet dryer, mechanical sieve and stainless steel perforated tray were obtained in the food processing laboratory of Federal Polytechnic Offa. All other chemicals used were of analytical grade.

Methods

Preparation of OFSP flour

The OFSP were purchased and were processed immediately on its arrival at the laboratory. The roots was washed, peeled and cut into thin pieces manually. One portion served as control sample and the rest as treated samples

Treatment

Water blanching: A portion of 400g of orange fleshed sweet potato was blanched using hot water for 3min at 60ºC. The orange fleshed sweet potatoes were introduced into the saucepan when the water reached a temperature of 70ºC

Steam blanching: Another portion of 400g of orange fleshed sweet potato was steam blanched using rice steam cooker (model: QRCSG-2800, Qlink Group China) for 3min at 100ºC

Grilling: Another portion of 400g of orange fleshed sweet potato was grilled using a gas cooker for 3mins at 60ºC.

The control and treated samples were spread out uniformly on a stainless steel perforated tray and dried in a cabinet dryer at 65ºC for 48hr, milled using laboratory hammer milling machine (Fritsch, D-55743, Idar-oberstein-Germany), and sieved using 450µm screen to obtain fine flour. The orange fleshed sweet potato flour was packed, sealed in polyethylene bags at ambient temperature (26±2°C) and 760mmHg for further analyzes

Preparation of OFSP extruded pasta products

Two hundred gram of each sample was weighed; 30g of carbon methyl cellulose, a pinch of salt was added to the weighed flour, mixed thoroughly. One egg was beat inside the mixture and it was also mixed thoroughly. The required quantity of water of about 50 to 60mL was added, mixed thorough with 10 to 15mL of oil to form dough. The dough was poured in an already oiled nylon and cooked for 15min. The hot dough was kneaded immediately in a kneading machine, and pass through an extruder machine of small opening by taking advantage of pressure differential that exist between the internal and exterior of the chamber. The machine cut it shapes to the desired, and oven dry at 58°C for 30 min. Each of the sample extrudates was cooked; keep for further analysis in tight polyethene nylon.

Proximate Composition of processed OFSP flour

The approved AOAC method (2005) was used to determined moisture content, crude protein, crude fat, crude fibre and total ash, while carbohydrate were calculated by difference.

Functional properties determination of processing OFSP flour

The method of Onwuka (2005) was used to determine bulk density, while swelling power and solubility were determined using the method of Takashi and Siebel (1988). Oil and water absorption capacities were determine with the method of Beuchat (1977), while wettability was determine with the method described by Okezie and Bello (1988)

Chemical determination of OFSP flour

The method of Swain (1979) was used for the determination of tannin contents, while total carotenoid was determined using Spectrophotometric methods described by Kimura and Rodriguez-Amayal (2004). The method described by Dubois *et al.,* (1956) was used to determine the total starch and sugar.

Sensory attributes of OFSP extruded pasta products

The method described by Iwe (2002) was used. The sensory panelists consisted of 50 consumers who are familiar with whole wheat pasta products. They were asked to rate the products in terms of colour, appearance, aroma, taste, texture, flavour, crispness and overall acceptability using a 9-point Hedonic scale (1=dislike extremely, 5= neither like nor dislike, 9= like extremely).

Statistical analysis

All data were statistically analyzed using SPSS version 21.0 for analysis of variance, while Duncan multiple range test (DMRT) was used to separate means where there is a significant difference. For each sample, triplicate determinations were carried out.

Results and discussion

Table 1 shows the proximate composition of various methods of processing orange flesh sweet potato into flour. All the sweet potato flour differs significantly in proximate composition as affected by the treatment and drying methods. Moisture content of flour is indicative of dry matter of the flour. The moisture content range from 7.76 to 8.49% with the control sample having the lowest while the grilled sample had the highest. Moisture content of the flour obtained in this study is within the range of 2.50 – 13.2% reported for orange flesh sweet potato flour (Hal, 2000; Osundahunsi *et al.,* 2003; Aina *et al.,* 2009). Moisture content of orange flesh sweet potato flour is considered a quality characteristic where storage is concerned, since water can accelerate chemical or microbiological deterioration (Van Hal, 2000). Since moisture content is directly related not only to drying method, but also condition of temperature and time (Falade and Solademi, 2010), the moisture content could be controlled to a desired level bearing in mind other quality requirements other than storage alone.

The protein content of the OFSP flour ranged from 3.14 to 6.57 with the control sample having the highest protein content while the blanched sample had the lowest protein. Protein is essential in the human diet for growth and it can be utilized to perform functional roles in food formulations. OFSP is regarded as a high energy, low protein food, however its protein in both fresh and flour form has been reported to be of good value (Hal, 2000; International Life Sciences Institute ILSI, 2008). Hence, it could serve as a fairly important protein source among low income consumers in developing countries whose diets contains protein derived mostly from fruits and vegetables.

The fat content of the flour blends ranged from 13.94 to 25.66% with grilled sample having the lowest content while the control sample cocoyam flour had the highest.The decrease in fat content of the blends might be attributed with the oxidation of fat during the period of drying of the samples (McGill *et al.,* 1974). The crude fibre range between 2.83 and 3.20% with control sample having the highest while the grilled sample had the lowest. Significant differences ($p<0.05$) was observed in the crude fibre content of the OFSP. Fibre has been reported to help in aiding digestion (Marer and Martin 2003). Fibre has been reported to play a vital role in the prevention of several diseases such as irritable colon, cancer and diabetes (Slavin, 2005; Elleuch *et al.,* 2011). Fibre consumption also soften stools and lowers plasma cholesterol level in the body (Norman and Joseph, 1995).

Ash content is a reflection of the mineral content of a food material. The ash content of OFSP ranged from 2.70 to 3.01%, control sample recorded the lowest ash content while the grilled sample recorded the highest ash content. The result obtained in this study is an indication of the presence of inorganic nutrients in the flour samples, therefore the samples could be a good source of mineral elements in the products. However, the decrease in the protein, fat and crude fibre obtained in this work might be due to different methods of processing into flour and the pretreatment used (Woolfe, 1992; Hal, 2000). Jangchud *et al.,* 2003) and Osundahunsi *et al., 2*003) reported that pretreatments involving leaching such as blanching, grilling decrease the protein, crude fibre, and crude fat of flour samples.

The carbohydrate content of the OFSP flour accounts for the bulk of the flour and hence, serves as a good energy source (Woolfe, 1992). The carbohydrate content ranged from 56.31 to 68.45% with the control sample recording the lowest carbohydrate content while the grilled sample recorded the highest. All the flour samples were high in carbohydrate, sweet potato has been reported to be rich in carbohydrate, this implies that the flour would be a source of high energy and nutrients dense food for consumers. (Igbabul *et al.,* 2014). Carbohydrate has been reported to be major sources of energy in the body, muscles and blood. It also contributes to fat mechanism, acts as mild natural laxative, and spares proteins as an energy source (Gaman and Sherrington, 1996; Gordon, 2000).

Table 1: *Proximate composition of processed OFSP flour (%)*

Sample	Moisture Content	Crude Protein	Crude Fat	Crude Fibre	Total Ash	Carbohydrate
A	$7.76±0.12^a$	$6.57±0.32^c$	$25.66±0.14^b$	$3.20±0.18^d$	$2.70±0.00^a$	$56.31±2.11^d$
B	$8.28±0.08^c$	$3.14±0.10^b$	$15.26±0.86^b$	$3.22±0.06^b$	$2.76±0.30^b$	$67.34±0.92^b$
C	$8.44±0.00^b$	$3.95±0.26^a$	$17.22±0.39^c$	$3.19±0.13^b$	$2.89±0.19^c$	$64.32±1.33^c$
D	$8.49±0.61^b$	$3.29±0.18^a$	$13.94±1.30^a$	$2.83±0.17^a$	$3.01±0.01^c$	$68.45±1.64^a$

A-Control sample; B-Blanched sample; C-Steamed sample; D-Grilled sample
Mean values with different superscripts within the same column are significantly different ($p <0.05$).

Table 2 shows the functional properties of various methods of processing orange flesh sweet potato into flour. The functional properties of flour are those that directly determine their end uses. It has been established that the composition and nature of macromolecules (proteins, fat, and carbohydrates) in food materials often affect their functionality (Prinyawiwatkul *et al.,*1997; Hung and Morita, 2003). There was no significant ($p>0.05$) difference in the bulk densities of the samples. The loose and packed density ranged from 0.520 to 0.550g/ml and 0.683 to 0.719g/ml respectively. The lower the bulk density value, the higher the amount of flour particles that can stay together and thus increasing energy content that could be derivable from such flour (Onimawo and Egbekun, 1998). The Loose Bulk Density (LBD) which is the lowest attainable density without compression was least for sample B (0.520) and highest for sample D (0.585) though the difference was very slight. The Packed Bulk Density (PBD) which is the highest attainable density with compression was slightly increased among the samples. The very slight increase in sample might be due to experimental errors. The bulk density is influenced by particle size and the density of the flour and is important in determining the packaging requirement and material handling (Karuna *et al.,* 1996). Plaami (1997) reported that bulk density is influenced by the structure of the starch polymers and loose structure of the starch polymers could result in low bulk density.Water absorption capacity (WAC) is the ability of the starch or flour to absorb water, swell for improved consistency and texture. The water absorption capacity of the flour ranged from 212.0 to 370.5% with sample A having the lowest while sample C had the highest. The WAC of OFSP flour in this study is much higher than reported values (173 – 175%) by Osundahunsi *et al., 2*003) for native and parboiled flour and this suggests that OFSP flour would hold large amounts of water during preparation to food products such as gruels and thus become voluminous with low energy and nutrient density (Cameron and Hofvander, 1982). Oil absorption capacity is attributed mainly to the physical entrapment of oils. It is an indication of the rate at which the protein binds to fat in food formulations (Onimawo and Akubor, 1999).

The oil absorption capacity of the OFSP flour ranges from 94.90 to 106.7% with sample B having the highest while sample C had the lowest. The high oil absorption capacity of OFSP flour suggests the lipophilic nature of the flour constituents (Ubbor and Akobundu, 2009) and it could be useful in food formulation where oil holding capacity is needed such as sausage and bakery products (Adejuyitan *et al.,* 2009). The solubility index and swelling power of the OFSP flour ranged from 9.85 to 21.9 and 710.1 to 821.9% with sample D having the highest value, while sample A had the lowest value for solubility index and swelling power, respectively. The swelling power is an indication of presence of amylase which influences the quantity of amylose and amylopectin present in the OFSP flour. Moorthy and Ramanujam (1986) reported that the swelling power of flour granules is an indication of the extent of associative forces within the granule. Swelling power is also related to the water absorption index of the starch-based flour during heating (Loss *et al.,* 1981). Therefore, the higher the swelling power, the higher the associate forces (Ruales *et al.,* 1993).

The variation in the swelling power indicates the degree of exposure of the internal structure of the starch present in the flour to the action of water (Ruales *et al.,* 1993).The values of the wettability ranged between 25 and 47sec. Sample A had the highest wettability while sample D had the lowest. There was significant difference (p<0.05) among the various method used for processing OFSP into flour. Wettability is a function of ease of dispersing flour samples in water and the sample with the lowest wettability dissolve fastest in water.

Table 2: *Functional properties of the processed OFSP flour*

Sample	LBD (mg/mL)	PBD (mg/mL)	WAC %	OAC %	SI %	SP %	WETABILITY (SEC)
A	0.54±0.11^{a}	0.68±0.06^{a}	212.00±0.00^{d}	96.71±1.61^{b}	9.85±0.72^{a}	710.10±4.81^{a}	47.00±1.37^{d}
B	0.52±0.00^{a}	0.72±0.00^{a}	241.30±0.01^{c}	106.70±3.53^{b}	15.00±0.33^{b}	730.90±6.03^{b}	43.50±1.01^{b}
C	0.54±0.21^{a}	0.72±0.12^{a}	370.50±0.03^{b}	94.90±2.10^{c}	21.00±0.00^{c}	795.50±1.08^{c}	26.50±0.86^{b}
D	0.55±0.08^{a}	0.69±0.15^{a}	295.10±0.10^{a}	105.50±2.98^{a}	21.90±0.41^{d}	821.90±5.68^{d}	25.00±0.43^{a}

A-Control sample; B-Blanched sample; C-Steamed sample; D-Grilled sample
LBD- loose bulk density; PBD-Packed bulk density, WAC-Water absorption capacity, OAC- Oil absorption capacity, SI-Solubility index, SP-Swelling power
Mean values with different superscripts within the same column are significantly different (p <0.05).

Table 3 shows the chemical analysis on various methods of processing of OFSP into flour.

The tannin content ranged between 993.6 to 779.2mg/kg with sample B having the highest tannin content while sample A had the lowest. Tannins have astringent properties that hasten the healing of wounds and prevention of decay. Carotenoids are compounds found in plants that can enhance the human health immune response and reduce the risk of degenerative diseases such as cancer, cardiovascular diseases, cataracts (Astrog,1997; Olson, 1999) and also important due to their conversion to vitamin A. The total carotenoid ranged from 39.48 to 67.06μg/100g with sample C having the lowest value while sample D had the highest value. The results obtained in this study were in agreement with the study of Astrog (1997). Variation in retention of carotenoids may be due to the difference in the enzymatic oxidation during processing.

Sweet potato contains free sugar that arises during maturity and post harvest handling of the root crop (Morrison *et al.,* 1993; Babu *et al.,* 1994). The analysis of total sugar in this study was focused on glucose, fructose and sucrose. The total sugar ranged from 2.30 to 6.83%. Sample A had the highest total sugar content, while sample B had the lowest. Zhang *et al.,* (2002) reported a ranged of OFSP total sugar to be between 4.8 and 12.5% which was very close to the result obtained in this study. The difference in total sugar could be due to the method used for processing and the time of harvest of each sweet potato Nabubuya *et al.* (2012) reported that the time of harvest of sweet potato had a significant effect on the total sugar content. Starch is quantitatively the most important component of sweet potato root dry matter. The damaged starch content of OFSP flour ranged from 2.91-3.43%, with sample A recording the highest value of damage starch.

The variation obtained in this result may be due to the pretreatment used in the processing method, mode of extraction method and analysis method (Soison *et al.,* 2015).The starch content of a food material affects certain properties like swelling, gelatinization, pasting and suitability for processing that food material (Waramboi *et al.,* 2010). Other properties of starch includes: granule shape, size and structure also affect the qualities of food products (Tian *et al.,*1991)

Table 3: *Chemical analysis of the processed OFSP flour*

Sample	Tannin (mg/kg)	Total carotene (μg/100g)	Total sugar (%)	Damage starch (%)
A	779.20±4.12^{a}	63.10±1.10^{c}	6.83±0.67^{d}	3.43^{d}
B	933.60±6.83^{c}	47.40±0.99^{b}	2.30±0.11^{a}	3.08^{b}
C	824.40±2.07^{b}	39.48±0.45^{a}	3.01±0.34^{b}	2.91^{a}
D	927.80±5.24^{c}	67.06±1.33^{c}	5.54±0.82^{c}	3.37^{c}

A-Control sample; B-Blanched sample; C-Steamed sample; D-Grilled sample
Mean values with different superscripts within the same column are significantly different (p <0.05).

Table 4 showed the results of the sensory evaluation of the extruded pasta products are presented. Colour is an important sensory attribute of any food because of its influence on acceptability. The colour of the sample valued ranged from 6.5 to 7.1 with sample C having the highest value of likeness while sample B had the lowest value of likeness. Appearance is the visual quality of the product (Spaghetti).The appearance of the extruded pasta product ranges from 6.2 to 6.8 with extruded pasta product from sample B having the highest likeness while sample A had the lowest likeness. Aroma is another attribute that influences the acceptance of pasta product even before they are tasted. The aroma ranged from 6.3 to 6.8. Sample C had the highest likeness for aroma while sample A had the lowest likeness for aroma. There were significant differences ($p<0.05$) in the taste attribute of the extruded pasta product. The taste ranged between 6.1 and 6.8 with sample B and C having the highest likeness. Texture is the quality of the extruded pasta product that can be decided by touch, the degree to which it is rough or smooth, hard or soft. The texture of the extruded pasta product ranged from 6.2 to 7.2. Sample A had the highest likeness while sample D had the lowest likeness value. The flavour and the crispness of the extruded pasta products ranged from 4.8 to 7.8 and 6.1 to 7.8 respectively. Sample B had the highest likeness for flavour and crispness while sample A and D had the lowest value for likeness for flavour and crispness respectively.

Significant differences ($p<0.05$) were observed among the processing various methods of OFSP into extruded pasta products in terms of overall acceptability. Extruded pasta product prepared from Sample A had the highest value of likeness with 8.5 while extruded pasta product prepared from sample D had the lowest value of 6.2. It was observed that likeness of extruded pasta products samples decrease based on the pretreatments used. This shows that all the samples based on their pretreatment and processing method were all accepted by the panelist.

Conclusions

The study showed that protein and the fat content of the orange fleshed sweet potato flour decreased based on the pretreatment and processing method. The pretreatment and processing methods had a significant effect on the functional properties and the chemical analysis of the OFSP flour except the loose and pack bulk density. However, all the samples based on their pretreatment and processing method were all accepted by the panelists. Therefore, the study showed that orange fleshed sweet potatoes could be used for pasta production that is rich in vitamin especially beta carotene.

Table 4: *Sensory attributes of the OFSP extrudates*

Sample	Colour	Appearance	Aroma	Taste	Texture	Flavour	Crispiness	Overall Acceptability
A	6.8 ± 0.22^{a}	6.2 ± 0.14^{a}	6.3 ± 0.08^{a}	6.1 ± 0.03^{b}	7.2 ± 0.13^{a}	4.8 ± 0.07^{a}	7.2 ± 0.00^{b}	8.5 ± 0.01^{a}
B	6.5 ± 0.16^{a}	6.8 ± 0.01^{b}	6.4 ± 0.05^{a}	6.8 ± 0.15^{c}	7.0 ± 0.28^{a}	7.8 ± 0.31^{c}	7.8 ± 0.19^{c}	8.3 ± 0.26^{b}
C	7.1 ± 0.03^{b}	6.7 ± 0.08^{b}	6.8 ± 0.22^{a}	6.8 ± 0.22^{c}	6.4 ± 0.16^{b}	6.0 ± 0.11^{b}	6.3 ± 0.32^{a}	6.3 ± 0.07^{b}
D	6.9 ± 0.19^{a}	6.5 ± 0.03^{b}	6.7 ± 0.18^{a}	5.8 ± 0.18^{a}	6.2 ± 0.11^{b}	6.7 ± 0.23^{b}	6.1 ± 0.16^{a}	6.2 ± 0.13^{b}

A-Control sample; B-Blanched sample; C-Steamed sample; D-Grilled sample
Mean values with different superscripts within the same column are significantly different ($p<0.05$).

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